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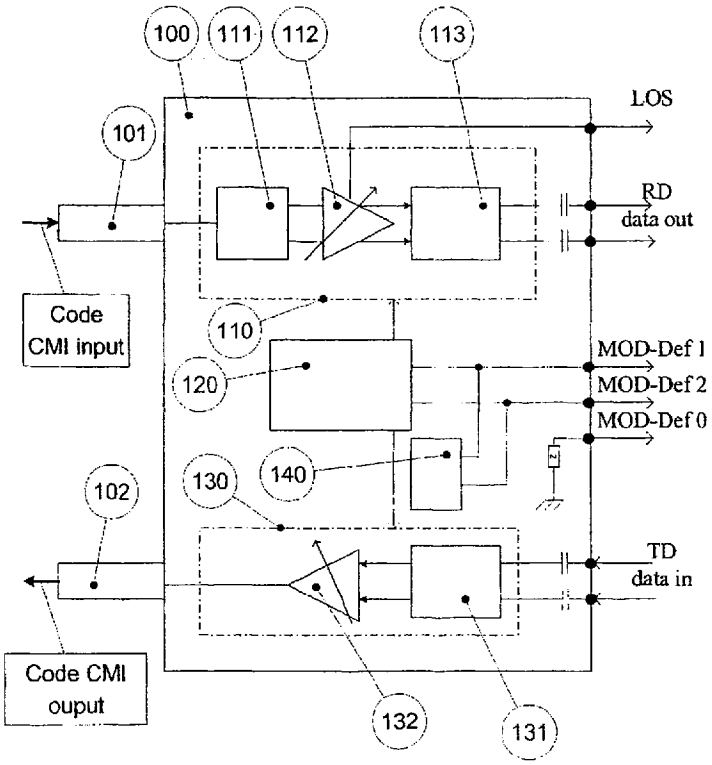
(54) Configurable electrical transceiver in a small form factor pluggable module realising coded interfaces

(57) The invention concerns an electrical transceiver which realises both of the SDH-STM1/Sonet-STS3 and PDH-E4 ITU-T G.703 CMI (Code Mark Inversion) coded interface.

That electrical transceiver is realised in a Small Form Factor Pluggable Module and can be programmed as STM1/STS3 or E4-PDH by simply applying the right configuration on the Serial Identification interface.

This allows to adopt the same interface for both applications and to specialise it on field at the moment of its utilisation (Fig. 1).

FIG. 1



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Description

Field of the invention

[0001] The present invention relates to an electrical transceiver which realises both of the SDH-STM1/Sonet-STS3 and PDH-E4 ITU-T G.703 CMI (Code Mark Inversion) coded interface.

[0002] The claimed electrical transceiver is realised in a Small Form Factor Pluggable Module and can be programmed as STM1/STS3 or E4-PDH by simply applying the right configuration on the Serial Identification interface.

[0003] This allows to adopt the same interface for both applications and to specialise it on field at the moment of its utilisation.

Background art

[0004] In the Sonet/SDH standards, the STM1/STS3 interfaces are specified in two different versions according to the nature of the signal adopted for the transmission.

[0005] The signal format can, in fact, be either electrical or optical :

- The electrical signal is normally used for intra station connections;
- The optical format can cover, with different implementation, the short as well as the long haul connections.

[0006] These cards are normally multi-port; and the high degree of integration achieved today allows modularity of more than 10 interfaces/card.

[0007] Another type of transmission interface very popular before the advent of the SDH/Sonet, and still used in the telecom world, is the 144Mbit E4 of the Plesiochronous Digital Hierarchy (PDH).

[0008] The realisation within the transmission equipment of the two types of transmission interfaces (STM1/STS3 or PDH-E4) and two types of line card interfaces (optical or electrical), has required, until now, the implementation of distinguished units.

[0009] The development and implementation of the many variants of transmission interfaces, translate in :

- more development effort, in HW,SW and management,
- more cost for the customer,
- more items to handle,
- more spares parts,

and, particularly, no reusability in case of transition from electrical to optical or from Plesiochronous to synchronous.

[0010] The recent advent of Small Form Factor Pluggable (SFP) optical modules has reduced some of these problems within the category of the optical interfaces.

[0011] Several pluggable module designs and standards have been introduced in which a pluggable module plugs into a receptacle which is electronically connected to a host circuit board.

[0012] These standards offer a generally robust design which has been well received in industry and has been used to develop gigabit interface converter (GBIC) and optical converter (SOC) and providing an interface between a computer and a data communication network such as Ethernet or Fibre Channel.

[0013] Nevertheless, an electrical module, based on the Small Form Factor Pluggable (SFP) standard, that allows the implementation on a single card, of the STM1/STS3 or PDH-E4 transmission interfaces, in the electrical as well as in the optical format, is considered very useful.

[0014] Until now every type of interface was implemented on a different dedicated card. We had :

- Many STM1/STS3 optical interface card variants (according to the transmission span, and to the wavelength used as for the ITU G.957) : I-1, S-1.1, S-1.2, L-1.1, L-1.2, L1.3
- STM1/STS3 electrical interface card
- E4 PDH electrical interface card

[0015] Therefore, there is the need for a versatile module, configurable according to the SDH or PDH electrical standard and that allows the reusability of the same host circuit board in case of transition from electrical to optical line card interface and from Plesiochronous to Synchronous.

[0016] This means, for instance, that the E4-PDH variant of the card, still required for interfacing installed legacy equipment, will not risk to be thrown away when this legacy world will disappear, because it can easily be reused as electrical STM1/STS3 (by simple SW modification), or reused as optical STM1/STS3 interface (by substitution of the pluggable module).

[0017] This translates in the following advantages :

- Smaller number of items to handle for the customer
- Smaller number of spare parts to store
- The same card (in case of multi port card) can be shared between the electrical and optical interface: card number saving.

Summary of the invention

[0018] The present invention provides a configurable electrical transceiver having the features claimed in the main claim. More specifically, according to the present invention, an intelligent processing unit (ASIC) has benn developed able to handle signals for the STM1/STS3 as well as the PDH /E4 transmission interfaces.

[0019] According to one aspect of the invention, by adopting such ASIC, an host circuit board has been im-

plemented which can be used for all the following applications:

- STM1/STS3 optical;
- STM1/STS3 electrical;
- E4 PDH electrical,

by plugging-in an electrical transceiver module with the electrical or optical signal interface.

[0020] According to the above, the present invention concerns a Configurable Electrical Small form Factor Pluggable Module (CESFP) that is an electrical transceiver, electrically and mechanically compatible with the optical SFP module, realising in a very small space the SDH-STM1/Sonet-STS3 and PDH-E4 ITU-T G.703 CMI (Code Mark Inversion) coded interface.

[0021] The CESFP module can be programmed as STM1/STS3 or E4-PDH by simply applying the right configuration on the Serial Identification interface (pins MOD-DEF 1 and MOD-DEF 2).

[0022] This allows to adopt the same interface for both applications and to specialise it on field at the moment of its utilisation.

[0023] The CESFP module is packaged in a metal housing which slides in a metallic booth (receptacle plus electrical connector) placed on the host. The receptacle (cage) and the connector pin out are compliant to the Small Form-factor Pluggable (SFP) Transceiver Multi-Source Agreement (MSA) September 2000.

[0024] The transceiver consists of a printed circuit board having as input/output physical interfaces two different types of connectors:

- A couple of small coax cable connectors providing the line side front access.
- A 20-pad slide-in type connector that connects the module printed circuit board (signals, alarms, power and ground) to the female electrical connector placed on the host board.

[0025] The main functions implemented on the printed circuit board are:

- Power supply distribution
- Cable Equaliser
- CMI encoder and decoder
- Alarm detectors
- AC - coupled inputs and outputs data signals
- Configurable Timing signal generation section
- Serial interface for identification and configuration

[0026] The Figure 1 provides the electrical block diagram as described in the following sections.
In the **receive section**, the CMI coded line signal, is received via a small coax connector.
The CMI is a 1B2B non-return-to-zero code where each bit of information is coded into two transmission bits. A binary "0" is coded to "01" and a binary "1" is alternately coded with "00" or "11", thus there is at least one transition during every bit period. A cable equalisation circuit together with an amplifier provide the recover of the original signal shape and amplitude, deteriorated by the cable attenuation and generate the appropriate signal to drive the CMI decoder. The CMI decoder accepts a differential data input and with the support of an internal reference clock returns an NRZ coded data stream, which is routed via two coupling capacitors to the -connector- pads (pins RD+,RD-).

[0027] The Loss of signal (LOS) circuit monitors the power level of the incoming signal and generates an alarm when the received signal is below a pre-defined threshold.

[0028] The **transmit section** consists of a NRZ/CMI encoder and a transmit buffer.

[0029] The differential NRZ signal is received from the pad connector (pin TD+,TD-).

[0030] The NRZ data signal, AC-coupled, is routed to the coding circuit and converted into a CMI-coded stream with the support of an internal reference clock.

[0031] The transmit buffer provides an output signal capable of driving a 75 Ohm transmission line compliant with ITU-G.703. The transmit CMI coded signal is outputted on a coax cable connector.

[0032] The NRZ output/input high-speed balanced-signals are accoupled.

[0033] The coupling capacitors are large enough to let the SDH test pattern signal pass through without significant distortion or performance penalty.

[0034] In the **Configurable Timing signal generation section,** an on board VCO provides the clock reference required by the encoder/decoder to perform the CMI/NRZ and NRZ/CMI conversions.

[0035] The device can be configured via a2-wire clocked Serial Interface and set for the STS3/STM1 or PDH-E4 application.

[0036] This operation can be done by the host card controller when the module is already in field, and after it has been recognised as an electrical STM1(STS3)/PDH transceiver. This information being stored in the memory (EEPROM) placed on the module, at the moment of its assembling.

[0037] The 2-wire clocked serial interface (I2Cbus) provides access to an internal EEPROM memory where sophisticated identification information (figure 3) have previously been stored in an MSA compliant fashion:

- CESFP's characteristics
- Module manufacturer
- Other information.

[0038] The serial interface consists of :

- MOD-DEF 1 - the 2-wire serial interface clock signal
- MOD-DEF 2 - the 2-wire serial interface data signal

[0039] A **power supply section** supplies the CESFP

module.

[0040] A ground on the- MOD-DEF 0- pin indicates that the module is present.

Brief description of figures

[0041] The features of the present invention which are considered to be novel are set forth with particularity in the appended claims. The invention together with additional objects and advantages thereof maybe better understood from the following detailed description of a preferred embodiment, taken in conjunction with the accompanying drawings, in which:

Figure 1 provides the block diagram of the CESFP module.

Figure 2 provides the interface between the CESFP module and the host circuit board.

Figure 3 provides the identification information of the internal EEPROM memory.

Figure 4 provides the pin-out of the pad connector.

Description of the preferred embodiment of the invention

[0042] The embodiment of the invention, shown in the figures wherein like referenced numerals designate identical or corresponding parts, and described below refers to the device object of the invention.

[0043] Generally, the configurable electrical transceiver module (CESFP) is realised in a Small Form-factor Pluggable Module (SFP) and the receptacle (cage) and the connector pin out are compliant to a Multi-Source Agreement SFP optical transceiver.

[0044] The CESFP module is packaged in a metal housing which slides in a metallic booth (receptacle plus electrical connector) placed on the host.

[0045] The module includes a cover, a printed circuit board, a base and a couple of small coax cable connectors.

[0046] The invention will be better understood after a discussion of related material as shown in **Figure 1** that discloses the functional block diagram of the configurable electrical transceiver module (CESFP).

[0047] The printed circuit board (100) have a first end and a second end.

[0048] The first end of the board is connected to the couple of small coax cable connectors (101,102), the first one connector (101) providing the CMI code input from external coaxial cable, the second one connector (102) providing the CMI code output to the external coaxial cable.

[0049] At the second end, the printed circuit board have a 20-pad slide-in type connector that connects the printed circuit board (100) to a female electrical connector (201) placed on the host board (200).

[0050] Through the 20-pad connector, the circuit board (100) exchange, to/from the host board(200), signals, alarms, power and ground according to the pin-out provided in the table reported in figure 4.

[0051] The circuit board(100) have a receive section (110) that receives the line signal, in the CMI code format, through the connector (101).

[0052] A cable equalisation circuit (111) together with an amplifier (112) provides to recover the original signal shape and amplitude, deteriorated by the cable attenuation and generates the appropriate signal to drive the CMI decoder (113).

The CMI decoder (113) accepts a differential data input and with the support of an internal reference clock, belonging to the programmable internal timing reference circuit (120), returns an NRZ coded data stream (RD data out), which is routed via two coupling capacitors to the connector (201) of the host board (200) depicted in **figure 2**.

[0053] The Loss of signal (LOS) circuit monitors the power level of the incoming signal and generates an alarm when the received signal is below a pre-defined threshold.

[0054] The transmitting section (130) receives a differential NRZ signal (RD data in) from the connector (201) of the host board (200).

[0055] The NRZ data signal (RD data in), AC-coupled, is routed to the encoding circuit (131) and converted into a CMI-coded stream with the support of an internal reference clock belonging to the programmable internal timing reference circuit (120).

[0056] The transmit buffer (132) receive the CMI-coded stream and provides an output signal capable of driving a 75 Ohm transmission line compliant with ITU-G. 703. The CMI coded signal is transmitted by the coax cable connector (102).

[0057] In the programmable internal timing reference circuit (120), an on board VCO provides the clock reference required by the encoder/decoder to perform the CMI/NRZ and NRZ/CMI conversions.

[0058] The host card controller (202) can configure, via a 2-wire clocked Serial Interface, the programmable internal timing reference circuit (120), setting it for the STS3/STM1 or PDH-E4 application. Such serial interface consists of :

- MOD-DEF 1 - the 2-wire serial interface clock signal
- MOD-DEF 2 - the 2-wire serial interface data signal

[0059] The host card controller (202) can recognise, via the MOD-Def0 pin, that the module is present and, via the MOD-Def1 and MOD-Def2 pins of the 2-wire clocked serial interface (I2Cbus), can access the internal EEPROM memory (140) where sophisticated identification information (Table reported in Figure 3) have previously been stored in an MSA compliant fashion:

- CESFP's characteristics
- Module manufacturer
- Other information.

[0060] The CESFP information stored in the memory, read through the serial interface, will inform the host card controller that that module is an Electrical STM1/STS3/E4 transceiver whose final setting needs an appropriate programming according to the user network configuration.

[0061] The host controller, via the same serial interface, will input the chosen configuration.

[0062] Wile a preferred embodiment of the present invention has been shown and described, it should be understood that the present invention is not limited thereto since other embodiment may be made by those skilled in the art without departing from the ambit and scope thereof. In one of said other embodiment some circuits positioned, according to the above description, in the configurable module may be transferred to the host board (200).

[0063] In particular the CMI decoder (113) and the CMI encoder (131), together with the programmable internal timing reference circuit (120), can be placed on the host board instead of inside the CESFP module, either in a discrete form or integrated within an Application Specific Integrated Circuit (ASIC).

[0064] It is thus contemplated that the present invention encompasses any and all such embodiments covered by the following claims.

Claims

1. Configurable electrical transceiver module pluggable on a receptacle designed for receiving such module and electrically connecting such module to an host circuit board mounted within a chassis of a host system of the, said configurable electrical transceiver being **characterised by** the combination of the following means:

   - housing means of the Small Form Factor pluggable type, having a first end and a second end;
   - printed circuit means (100) mounted inside said housing means
   - coaxial connecting means (101, 102) mounted at the first end of said printed circuit means (100);
   - multipad electrical connecting means mounted at the second end of said printed circuit means (100);
   - receiving/transmitting means (110, 130) connected to said coaxial connecting means, to said multi-pad electrical means, and to configurable timing signal generation means (120).

2. The module of claim 1, **characterized in that** said receiving/transmitting means (110, 130) are including:

   - a receiving circuit section (110), receiving via a coaxial connector (101) of said coaxial connecting means the CMI data input from the line signal, converting such data to an NRZ coded data stream by means of a CMI decoder (113) and an internal timing reference circuit (120), and routing the NRZ coded data to an host circuit board through said miltipad electrical connecting means;
   - a transmitting circuit section (110), receiving via said electrical connector the NRZ coded data stream from an host circuit board, converting such data stream to an CMI coded data output by means of a CMI encoder (131) and said internal timing reference circuit (120), and routing the CMI data output to the line interface via a coaxial connector (102) of said coaxial connecting means;

3. The module of claim 2, **characterised in that** said configurable timing signal generation section (120), includes an on board VCO and a 2-wire clocked serial interface connected with the host card controller.

4. The module of claims 2 and 3, **characterised in that** the timing signal generation section provides the clock reference required by the decoder to perform the CMI/NRZ and NRZ/CMI conversions.

5. The module of the previous claims, **characterised in that** the a 2-wire clocked serial interface is used for the in-field programming of the module as STM1/STS3 interface type.

6. The module of the previous claims, **characterised in that** a 2-wire clocked serial interface is used for the in-field programming of the module as PDH-E4 interface type.

7. The module of claim 2, **characterized in that** said receiving/transmitting means (110, 130) are also including an amplifier (112) connected at the imput of said CMI decoder (113) and adapted to generate a signal (LOS) monitoring the power level of the incoming signal and driving a circuit of the host system adapted to generate an alarm when the received signal is below a pre-defined threshold.

8. The module of claims 5 and 6, **characterised in that** is adapted to be used in combination with a host system of the type including a card controller and said in field programming is done by the host card controller when the module is already in field.

9. The module of the previous claims, **characterised in that** includes memory means able to store identification information and able to be connected via said 2-wire clocked serial interface to the host card

controller programming the interface type disclosed in claim 5 or the interface type disclosed in claim 6.

10. The module of claim 9, **characterised in that** said memory means are of the EEPROM type and said identification information are stored in an multi-source agreement compliant fashion.

11. The module of the claims 1 to 6, **characterised in that** is adapted to be used in combination with a host system of the type including a card controller connected to ground via a pin of the module in order to recognise if the module is present.

12. The module of claim 2, **characterised in that**:

- said CMI decoder (103);
- said CMI encoder (131);
- said internal timing reference circuit (120),

are placed on the host system and are connected to said receiving/transmitting means via said multi-pad electrical connecting means (100).

FIG. 1

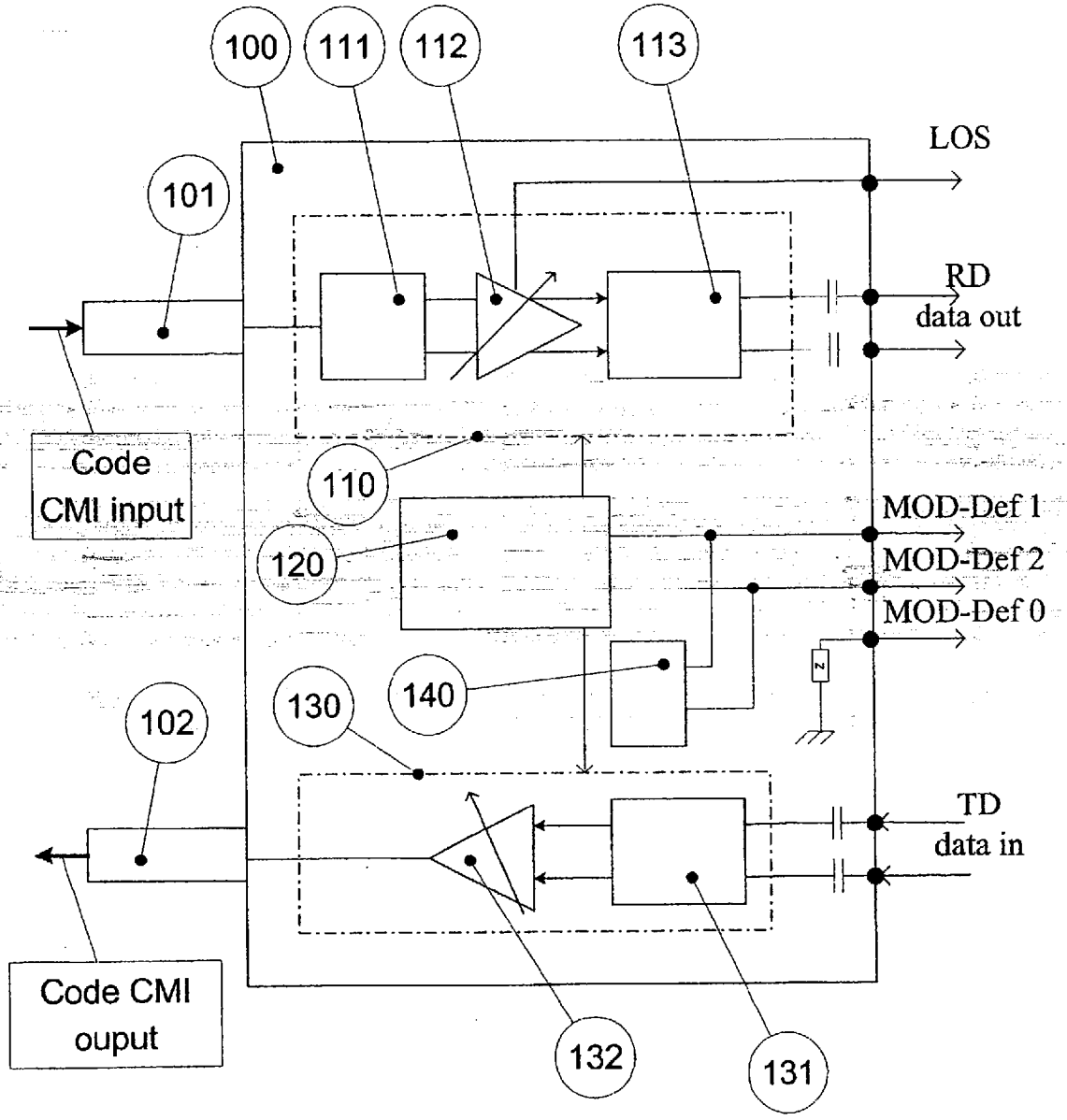
100
111
112
113
LOS
101
RD
data out
Code
CMI input
110
120
MOD-Def 1
MOD-Def 2
MOD-Def 0
130
140
102
TD
data in
Code CMI
ouput
132
131

FIG. 2

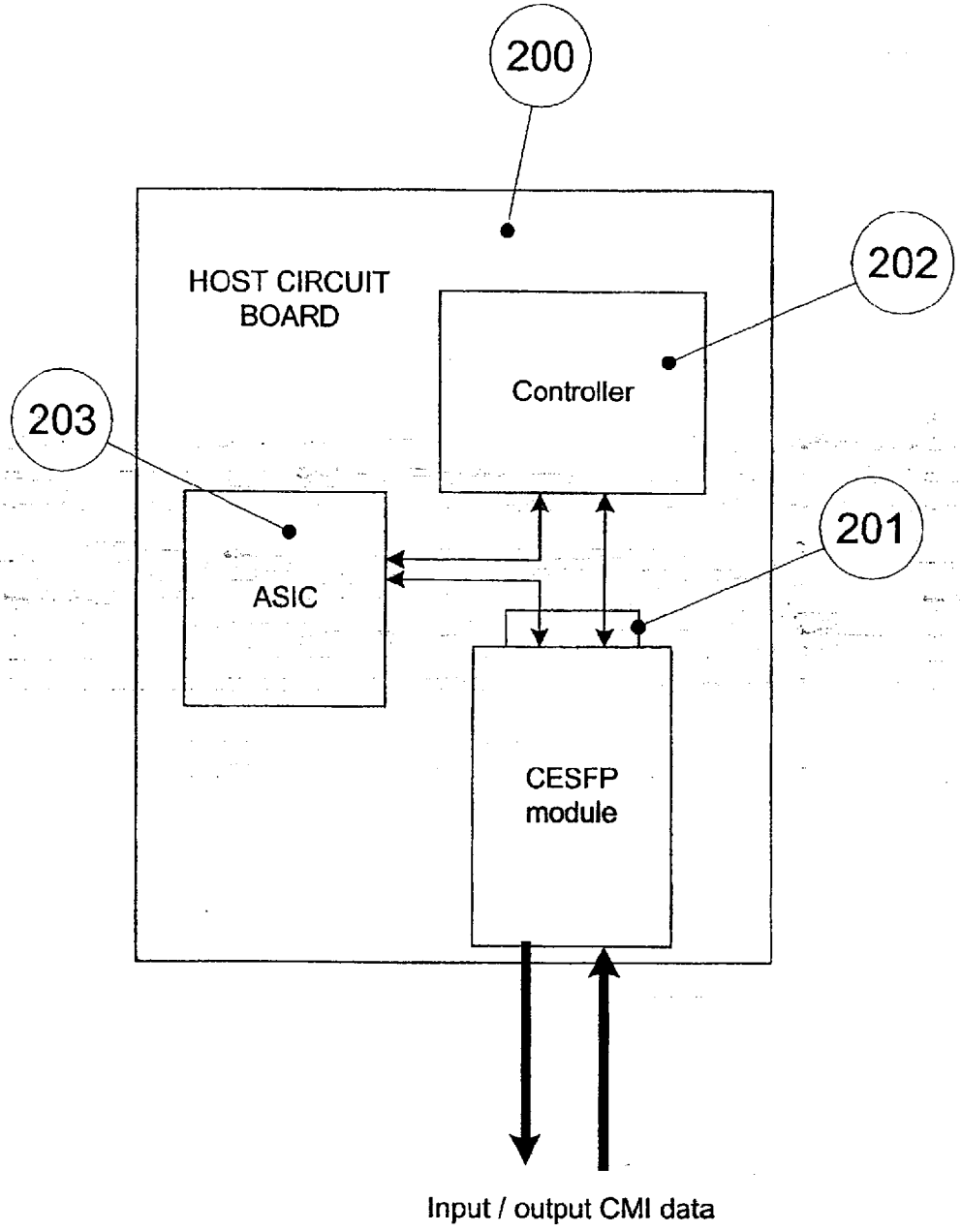
200
HOST CIRCUIT BOARD
202
Controller
203
ASIC
201
CESFP module
Input / output CMI data

FIG. 3

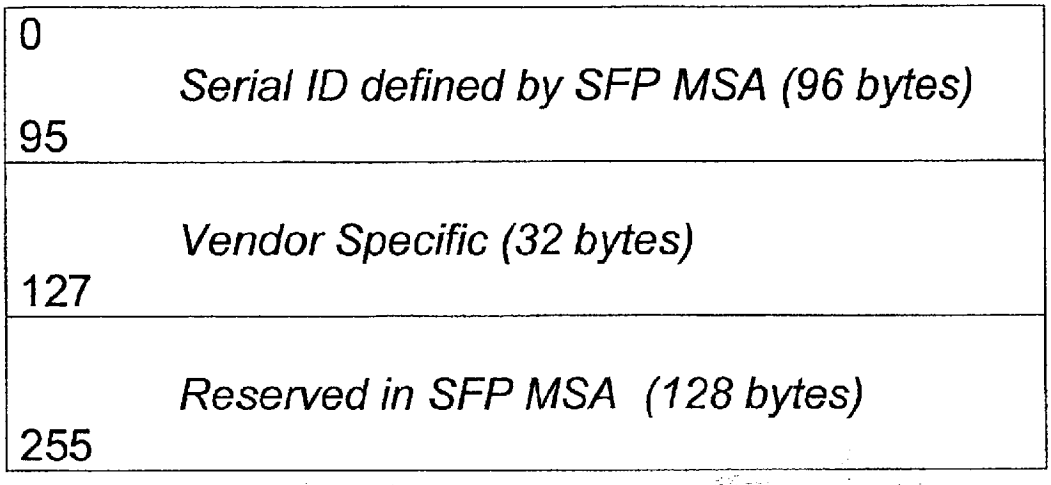

FIG. 4

1	TX-Ground	11	RX-Ground
2	NC	12	RD- inv. receiver data Out
3	NC	13	RD+ receiver data Out
4	MOD-DEF 2	14	RX-Ground
5	MOD-DEF 1	15	VccR
6	MOD-DEF 0	16	VccT
7	NC	17	TX-Ground
8	LOS	18	TD+ transmit data In
9	RX-Ground	19	TD- inv. transmit data In
10	RX-Ground	20	TX-Ground

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 42 5123

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	GUINEA J ET AL: "A Single Chip 155Mbps/140Mbps SDH/PDH Transceiver" PROCEEDINGS OF THE IEEE 2000 CUSTOM INTEGRATED CIRCUITS CONFERENCE, ORLANDO, FL, USA, 21 - 24 May 2000, pages 315-318, XP002249905 * the whole document * ---	1-12	H04Q11/04
D,Y	SMALL FORM-FACTOR PLUGGABLE (SFP) TRANSCEIVER MULTISOURCE AGREEMENT (MSA), 14 September 2000 (2000-09-14), pages 1-38, XP002249906 * the whole document * -----	1-12	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H04Q
H04J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 August 2003	Vercauteren, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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